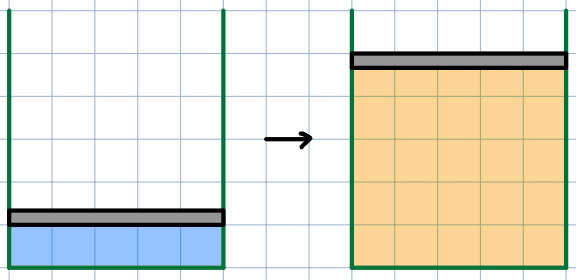
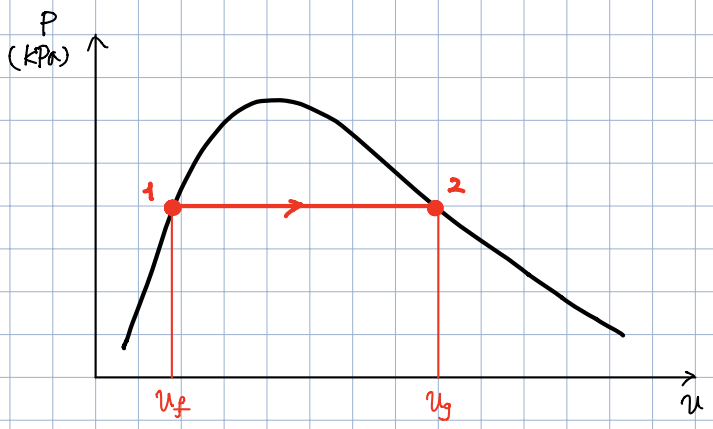
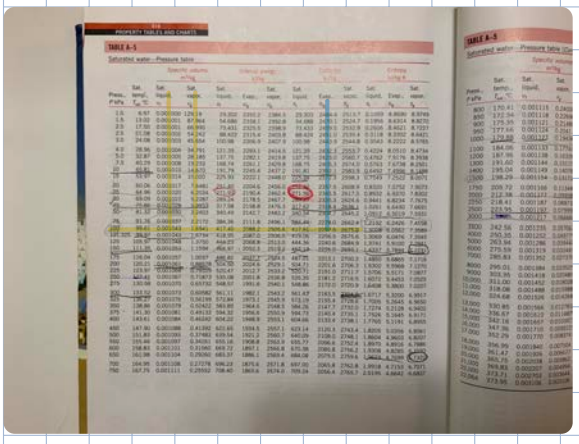






a) the Volume change

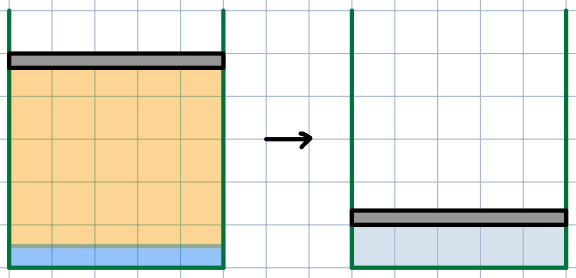
$$v_{fg} = v_g - v_f$$
$$= (1.6941) - (0.001043)$$
$$= 1.6931\ m^3/kg$$

$$\Delta V = m v_{fg} = (0.2\,kg) \cdot (1.6931\ m^3/kg)$$
$$= 0.3386\ m^3$$

b) the amount of energy transferred to the water

Energy → the enthalpy of vaporization at that pressure

$$E = m h_{fg} = (0.2\,kg) \cdot (2257.5\ kJ/kg) = 451.5\ kJ$$



$T_1 = 25°C$
$p_1 = 100\ kPa$
air + liq. water (1 kg)
$V_1 = 1\ m^3$

$T_2 = 180°C$
air + water vapor
$V_2 = 0.1\ m^3$

Air, ideal gas

$C_v = 0.728\ kJ/kg\cdot K$
$R = 0.287\ kJ/kg\cdot K$

$C_p - C_v = R$
$C_p = C_v + R$

a) State 2 is ideal mixture → $p_2 = ?$
(Neglect any air dissolved in water)

b) $pV^n = const$ → $W = ?$

c) Determine the heat transfer from the surrounding

(a) State 2 = air + water vapor

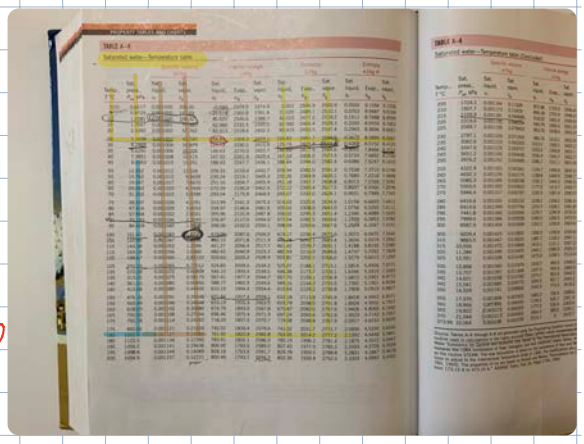
$p_2 = p_{2,air} + p_{2,wv}$

$pv = RT$
$p = mRT/V$

State 1: Table A-4 : $T_1 = 25°C$ → $p_{sat} = 3.17\ kPa$

air + liq. water → $p_1 = p_{1,wl} + p_{1,air} = 100\ kPa$

$\therefore p_{1,air} = 96.83\ kPa$



$p_1V_1 = mRT_1$ → $m = p_1V_1/RT_1$ (∵ Volume occupied by liquid is neglected)

$$m_{air} = \frac{(96.83\ kPa)\cdot(1\ m^3)}{(0.287\ kJ/kg\cdot K)\cdot(298\ K)} = 1.13\ kg$$

State 2:

$p_2V_2 = mRT_2$

$$p_{2,air} = \frac{mRT_2}{V_2}$$

$$= \frac{(1.13)\cdot(0.287)\cdot(453)}{(0.1)} = 1469.1\ kPa$$

Table A-4 : $T_2 = 180°C$ → $p_{2,wv} = 1002.8\ kPa$

→ $p_2 = (1469.1\ kPa) + (1002.8)$
$= 2471.9\ kPa$

Ans. (a)

(b) $pV^n = const$ → $W = ?$

$$W = \int_{V_1}^{V_2} p\,dV \leftarrow pV^n = C$$

$$\vdots$$

$$= \frac{p_2V_2 - p_1V_1}{1-n}$$

$$= \frac{(2471.9)(0.1) - (100)(1)}{1-1.393}$$

$$= -374.53\ kJ$$

Ans (b)

$p_1V_1^n = p_2V_2^n$

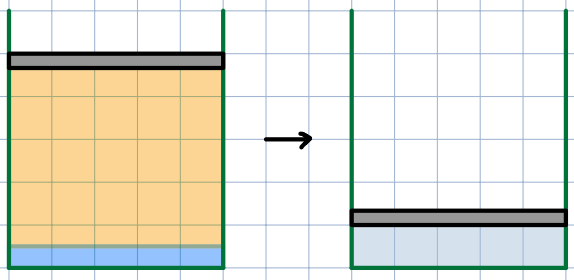
$(100)\cdot(1)^n = (2471.9)(0.1)^n$

$(0.1)^n = 100/2471.9$

$n\log(0.1) = \log(100/2471.9)$

$\therefore n = 1.393$

(c) Determine the heat transfer from the surrounding



$T_1 = 25^\circ C$
$p_1 = 100\ kPa$
air + liq. water (1kg)
$V_1 = 1\ m^3$

$T_2 = 180^\circ C$
air + water vapor
$V_2 = 0.1\ m^3$

Energy → the enthalpy of vaporization

$\Delta E = m h_{fg} = \Delta H = Q - W$

$Q = \Delta H + W$

$Q = \{\Delta H\}_{air} + \{\Delta H\}_{wv} + \{\Delta H\}_{wl} + W$

$m_{1,wl} = 1kg \longrightarrow V_2 = 0.1 m^3$

if all liq. water turned into sat. vapor, $v_2 = 0.1 m^3/kg$

Table A-4 : $T_2 = 180^\circ C \longrightarrow$ $v_f = 0.001127$
$v_g = 0.19384$.

$v_2 = V_2/m$
$v_g = V_2/m_{2,wv} \longrightarrow m_{2,wv} = V_2/v_g = \frac{0.1 m^3}{0.19384 m^3/kg} = 0.51589\ kg$

$m_{2,wl} = 1 - 0.51589 = 0.484\ kg$

$\{\Delta H\}_{air} = m_{air} \cdot C_p (T_2 - T_1)$ ← $C_p = C_v + R$
$= (1.13 kg) \cdot (1.015 kJ/kg.K) \cdot (180 - 25 K)$
$= 177.78 kJ$

$\{\Delta H\}_{wv} = m_{2,wv} \cdot h_{2,wv} - m_{1,wv} \cdot h_{1,wv}$ ← $T = 180^\circ C \rightarrow$ $h_f = 763.05$, $h_{fg} = 2014.2$, $h_g = 2777.2$

$= (0.51589\ kg) \cdot (1802.16)$
$= 929.73\ kJ$

$x_2 = \frac{0.51589 kg}{1 kg} = 0.51589 \rightarrow h_{2,wv} = h_f + x_2 (h_{fg}) = 1802.16$

$\{\Delta H\}_{wl} = m_{2,wl} \cdot h_{2,wl} - m_{1,wl} \cdot h_{1,wl}$

$= (0.484) \cdot (763.05) - (1) \cdot (104.83)$
$= 264.48\ kJ$

$Q = \{\Delta H\}_{air} + \{\Delta H\}_{wv} + \{\Delta H\}_{wl} + W$

$= (177.78) + (929.73) + (264.48) + (-374.53)$

$= 997.46\ kJ$

Ans. (c)